

Final Report

***MEETING TECHNOLOGY CHALLENGES FOR
THE 2007 HEAVY-DUTY HIGHWAY DIESEL
RULE***

Report of the

*Clean Diesel Independent Review Subcommittee
Clean Air Act Advisory Committee*

Presented to the Clean Air Act Advisory Committee
Washington, D.C.
October 30, 2002

I. Introduction

Emissions from heavy-duty vehicles contribute significantly to a number of serious air pollution problems. Heavy-duty vehicle emissions account for a significant portion of national PM and NO_x emission inventories. Among mobile sources, the U.S. Environmental Protection Agency (EPA) estimates that by 2007, these emissions will account for 28 percent of NO_x emissions and 20 percent of PM emissions. These proportions can be considerably higher in urban areas. Without stringent controls on heavy-duty vehicles, these serious air pollution problems would increase further.

Reviews by EPA and other public health agencies have found that ground-level ozone, particulate matter (PM), nitrogen oxides (NO_x), sulfur oxides (SO_x), and a number of volatile organic compounds (VOCs) adversely affect public health.^{1,2,3,4} These reviews have concluded that each of these pollutants contributes, or is likely to contribute, to one or more of the following health effects: premature mortality, cancer, aggravation of cardiovascular disease, and adverse respiratory effects including exacerbation of asthma, changes to lung tissues and structures, altered respiratory defense mechanisms, decreases in lung function and chronic bronchitis.

At the same time, heavy-duty vehicles are important contributors to the nation's transportation infrastructure, offering advantages of fuel efficiency, durability, performance and reliability.

EPA, the California Air Resources Board (CARB), other state and local agencies, engine and vehicle manufacturers, emission control manufacturers, and refiners have been working for the past decade to substantially reduce emissions from this source. In December 2000, EPA announced new heavy-duty engine and vehicle standards and highway diesel fuel sulfur control requirements. The Control of Air Pollution From New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements; Final Rule (2007 HD Rule) was promulgated on Thursday, January 18, 2001, and its emissions requirements will begin to take effect in model year 2007.⁵ This program is based on the use of high-efficiency catalytic exhaust emission control devices, particulate filters, and other advanced technologies. The standards also require reducing sulfur in highway diesel fuel by 97 percent (from 500 parts per million (ppm) to 15 ppm) by mid-2006. This 15 ppm sulfur highway diesel fuel (15 ppm fuel), coupled with advanced control technologies on vehicles, are projected to decrease PM and NO_x emissions to levels that are 90 percent and 95 percent below 2001 levels, respectively. Specifically, the PM emissions standard has been set at 0.01 g/bhp-h for model year 2007 for heavy-duty diesel vehicles. NO_x and non-methane hydrocarbon (NMHC) standards are set at 0.2 g/bhp-h and 0.14 g/bhp-h, respectively. These standards will be phased in together between 2007 and 2010, based on a percent-of-sales basis: 50 percent from 2007 to 2009, and 100 percent in 2010.

The 2007 HD Rule includes a combination of provisions available to refiners to assist in the transition to 15 ppm sulfur highway diesel fuel. These include a temporary compliance

option, referred to as the 80/20 option, including an averaging, banking, and trading component, beginning in June 2006 and lasting through 2009. Credit is also available for early compliance before June 2006. There are flexibility provisions for refiners subject to the Geographic Phase-in Area (GPA) provisions of the Tier 2 gasoline sulfur program (allowing them to stagger their gasoline and diesel investments), and hardship provisions for small refiners to minimize their economic burden in complying with the 15 ppm sulfur standard.

While state and local air agencies, environmental and public health organizations, and some industry stakeholders supported the 2007 HD Rule, other industry groups challenged specific provisions of the rulemaking in the United States Court of Appeals for the District of Columbia Circuit. After reviewing the arguments of the litigants and the rulemaking record, on May 3, 2002, the District of Columbia Court of Appeals upheld EPA's decisions on the 2007 HD Rule.

II. Background to the Clean Diesel Independent Review Panel

As part of the 2007 HD Rule, EPA agreed to conduct a biennial review of technology progress for reducing NO_x emissions. These technology review reports, which will be released and posted on the Web, will discuss the status of the technology and any implications for the heavy-duty engine emission control program. The first comprehensive review of the technologies needed to implement the 2007 HD Rule was conducted and published in June 2002.⁶

On July 30, 2001, EPA Administrator Christine Whitman announced that EPA would request an independent review to provide "advice to the EPA on technology issues associated with the introduction of technology to reduce engine exhaust emissions and technology to lower the sulfur level of highway diesel fuel in accordance with the dates incorporated in the highway diesel program promulgated in 2001." The independent review would be conducted in an open, public process following the requirements of the Federal Advisory Committee Act (FACA). The independent review would operate under the auspices of the FACA as a Subcommittee of the Clean Air Act Advisory Committee (CAAAC).

The Clean Diesel Independent Review Panel (CDIRP) was created by a charter issued under the CAAAC.⁷ The purpose of the CAAAC is to provide independent advice and counsel to the EPA on policy and technical issues associated with the implementation of the Clean Air Act (CAA) Amendments of 1990. The CAAAC has approximately 50 members from the regulated and private industry, the academic community, state and local government and environmental and public health organizations. The committee is authorized under the Federal Advisory Committee Act, 5 U.S.C., App. Section 9 (c). The CAAAC is normally consulted on a quarterly basis on economic, environmental, technical, scientific and enforcement issues. The results of these meetings are a written report providing advice to the EPA on implementing the CAA.

The CDIRP was chaired by Mr. Daniel Greenbaum, President of the Health Effects Institute (HEI), Boston, MA. Panel members included leading experts from the public health community, environmental organizations, petroleum refiners, fuel distributors and marketers, engine and vehicle manufacturers, emission control systems manufacturers, State governments, and academia (see Text Box). EPA representatives served as technical consultants to the panel. The Panel began its work in May 2002, and Administrator Whitman asked the panel to report its findings to her by mid-September 2002.

Members of the Clean Diesel Independent Review Panel	
Name	Affiliation
Daniel Greenbaum, Chair	Health Effects Institute
Sally Allen	Gary-Williams Energy Corporation
William Becker	STAPPA/ALAPCO
Bruce Bertelsen	Manufacturers of Emission Controls Association
Paul Billings	American Lung Association
Tom Bond	BP
Tom Cackette	State of California Air Resources Board
Pat Charbonneau	International Truck & Engine Corporation
Josephine Cooper	Alliance of Automobile Manufacturers
Timothy Johnson	Corning, Inc.
Bill Gouse	American Trucking Associations
Richard Kassel	Natural Resources Defense Council
James Kennedy	UOP LLC
Michael Leister	Marathon Ashland Petroleum LLC
Bob Neufeld	Wyoming Refining Company
Robert Sawyer	University of California at Berkeley
John Wall	Cummins Incorporated
Mike Walsh	Consultant
Alan Wright	Pilot Corporation
Designated Federal Official:	
Mary Manners	U.S. Environmental Protection Agency

The purpose of the CDIRP was to review industry's progress in developing the technologies necessary to implement the 2007 HD Rule. In the letter from Jeffrey Holmstead (April 16, 2002), the panel was charged to answer the following four questions⁸:

1. What is the current status of the NO_x adsorber technology to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop NO_x adsorbers in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007? What other technologies are being pursued/developed to enable or facilitate the application of NO_x adsorbers?
2. What is the current status of catalyzed diesel particulate filters to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop the catalyzed diesel particulate filter in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007?
3. Which refiners have announced their plans for producing low sulfur diesel fuel by June 2006? Where are refiners in their decision making/planning process for complying with the low sulfur diesel program requirements? Are the necessary resources and plans being put in place to ensure that refiners are on track for meeting the 15 ppm sulfur diesel standard in 2006?
4. What is the current status of new or improved desulfurization technologies?

The CDIRP held meetings in the Washington, D.C. area in May, June, July, and September of 2002. The Panel's review process included hearing presentations on technology progress and/or issues from EPA and other industry experts and stakeholders (see Appendix I).

Panel members and other interested parties also examined and commented on EPA's *Highway Diesel Progress Review* report.⁶ For this report, EPA interviewed virtually all the major engine, vehicle and catalyst manufacturers, refiners, and refinery technology vendors. The Agency concluded that although it is still early in the process, every major engine and vehicle manufacturer expects to have emission-compliant products by 2007. In addition, EPA concluded that the refining industry is where the Agency anticipated it to be, and some are actually ahead of schedule. Panel members and other stakeholders provided detailed comments on the report to EPA.

The primary focus of the panel's efforts was to provide its own answers to the Four Questions provided to the Panel by EPA. At its July Meeting, the Panel formed Working Groups to address these questions and the Panel's conclusions below resulted from the efforts of those Working Groups, and agreements reached by the Panel at its meeting of September 24-25, 2002. The Panel agreed unanimously to this report at its final meeting of September 25, 2002.

III. The Panel's Conclusions: Answering the Four Questions

Overall, the Panel found that there has been much progress toward the technology development necessary to implement the 2007 HD Rule. At the same time the Panel acknowledged that, as would be the case with any such rule where new technologies have to be developed and implemented, important progress remains to be accomplished. The Panel's specific response to the Four Questions are below:

1. What is the current status of the NO_x adsorber technology to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop NO_x adsorbers in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007? What other technologies are being pursued/developed to enable or facilitate the application of NO_x adsorbers?

2. What is the current status of catalyzed diesel particulate filters to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop the catalyzed diesel particulate filter in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007?

Over the course of three months of discussion and presentations, the Clean Diesel Independent Review Panel reached a consensus that significant progress is being made to develop emission control technologies for use in diesel engines starting in model year 2007. The Panel has also identified specific engineering challenges that must be resolved for successful final implementation. While there are other possible technologies that might be employed in 2007, the two that appear most likely, and which were given most attention by the EPA in its progress report, are NO_x adsorbers and catalyzed particulate filter systems. Consequently, these are the technologies given attention by the Panel.

NO_x Adsorbers

The Panel's review of NO_x adsorbers is a current "snapshot" of progress, taken eight years before full production compliance is required. The 2007 HD Rule does not require 100 percent compliance with the 0.2 g/bhp-hr NO_x standard until 2010. Reducing emissions from the 2004 standard of 2.4/2.5 g/bhp-hr (NO_x and NMHC combined) to 0.2 g/bhp-hr will require NO_x adsorbers that can operate reliably and durably at up to 95 percent efficiency. While there are important technical challenges that must be resolved before NO_x adsorbers can achieve this level, bench and dynamometer testing has already demonstrated adsorber efficiencies at 70 percent and more, leading Panel members to conclude that the technology is making significant progress toward successful implementation in the 2007-2010 timeframe. Given that full, industry-wide compliance with this standard is not required until 2010, this is a critically important finding.

The Panel noted that this rapid technology development is due to the certainty provided by the finalization of the 2007 HD Rule, which confirmed future sulfur levels and timetables for the new emission standards. Engine, vehicle, and emission control manufacturers are making tremendous investments now to ensure the successful development and implementation of the NO_x adsorber technology in time for the 2007 HD Rule's implementation.

Despite the significant progress, the Panel also discussed a number of technical challenges that must be resolved for the successful introduction of NO_x adsorbers in the 2007-2010 time frame. The Panel recognizes the lesser maturity level of the development of this device compared to particulate filters. The issues discussed by the Panel included:

Temperature range: NO_x adsorber efficiency must be expanded over a wider range of operating temperatures.

Durability: Improve NO_x adsorber efficiencies over the full useful life of the system (e.g., thermal durability).

Desulfation: NO_x adsorber efficiency is reduced by sulfur, so the adsorber must be "desulfated" periodically. Desulfation methods and performance require improvement.

System integration: including packaging constraints and fuel economy impacts.

Several Panel members also identified substrate issues and migration of precious metal elements for future resolution.

Some of these have been described in engineering terms as "fundamental technical issues." In each case, Panel members found significant commitment of resources to address these issues, and that progress is being made. Panel members agreed that technological challenges remain, but none is considered to be insurmountable at this time.

Improving the durability of the NO_x adsorber, especially as it relates to desulfation, is the most significant fundamental challenge that is being addressed currently. This will require further materials improvements, in addition to better temperature and air-fuel ratio control during the desulfation process. Recent progress is impressive, with some gasoline systems showing minimal deterioration, but these need to be adapted for diesel use. Many alternatives have been proposed for desulfating procedures and are in development. Adsorber technologists are assessing various options to determine which process best meets the needs of diesel applications.

Because of the state of maturity of the technology, the improvements are being driven by bench testing and dynamometer testing. Vehicle integration strategies and development are in the infant stages. NO_x adsorbers are not being tested and integrated into full heavy-duty diesel vehicles yet. However, it is important to note that they are being integrated into light-duty diesel vehicle systems that are demonstrating low NO_x emissions on the Federal Test Procedure. For

example, EPA tested a Toyota light-duty vehicle that demonstrated that a vehicle would be capable of meeting Tier 2 Bin 5. The vehicle was designed for the European market and will require additional development if Toyota elects to certify it to US emission standards. Nonetheless, this level of performance was formerly thought to be beyond the capability of light-duty diesel emissions control technology. While there are many differences between light-duty and heavy-duty diesel engines, vehicles, duty cycles and durability requirements, EPA and some Panel members thought the Toyota developments would be instructive to heavy-duty NO_x adsorber developers.

Catalyzed Diesel Particulate Filters (CDPFs)

The Panel reached consensus that PM filters will be necessary and available to meet the 2007 PM standard. Today's PM filters are the latest stage in more than twenty years of PM filter development in North America, Europe and Japan.

The Panel found that Catalyzed Diesel Particulate Filters (CDPFs) are more mature than NO_x adsorbers. At this point, transit buses, school buses and other diesel vehicles are being retrofitted with CDPFs and other particulate filters throughout the nation, and CDPFs are being used throughout Europe and elsewhere. Using passive PM filters in commercial applications enhances the development process towards a wider use of CDPFs by providing a wide range of real world usage.

International Truck and Engine Company has already certified a CDPF-equipped medium-heavy-duty engine at the 2007 PM standard as well as the 2007 hydrocarbon standard. These engines are limited to vehicle applications that fit the proper exhaust temperature profile and only use 15 ppm sulfur fuel.

CDPF developers are focusing on three primary areas of development as they prepare for 2007:

Active regeneration: Active regeneration will be required for all diesel vehicles with particulate filters in 2007 to ensure that the filter regenerates when the load factor is not sufficient for passive regeneration.

Ash handling: Further design enhancements of the filters will be required to minimize ash loading consequences. Development and use of very low ash oils will also be beneficial. Reliable service practices and infrastructure must be in place for filter cleaning, and acceptable service intervals must be established.

Pressure drop reduction: The design of the filter as well as the active regeneration strategies require further development to minimize the filter pressure drop and, thereby, improve vehicle fuel efficiency.

In addition to these three specific issues, full vehicle integration is an important development requirement, including integrating particulate filter systems with NO_x adsorber systems.

In sum, the Panel members are very encouraged with the state of development of CDPF's. While technical challenges remain, none is considered to be insurmountable at this time.

Summary of Responses to Questions 1 and 2

The Panel found that significant progress is being made to develop NO_x adsorbers and catalyzed particulate filter systems for use in diesel engines in 2007. NO_x adsorbers and catalyzed particulate filter systems are the primary technologies being developed by engine manufacturers, vehicle manufacturers and emission control manufacturers in North America, Europe and Japan for US applications in 2007. The worldwide focus on a particular technology significantly enhances its potential for success. In each case, the Panel found examples of significant progress that has occurred since the 2007 HD Rule was finalized in 2001.

Given the degree of progress on fundamental technology development, companies are rapidly moving beyond purely technical issues to address product development issues like fuel economy, cost reduction, reliability, long-term durability, and maintenance. Cost issues and other product development issues were beyond the Panel's discussion, since it did not have access to company confidential cost and other data. Many of these are "system level" issues, i.e., issues related to integrating emission control equipment with vehicle and engine platforms. Ensuring successful integration of emission control, engine and vehicle systems to produce the best product for the customer is a critical piece of the engineering and product development work that lies ahead.

In sum, the Panel is very encouraged by the rate of progress to date. Technical challenges remain to be resolved. However, Panel members agreed that, while we do not know the solutions now, none is considered to be insurmountable at this time. The next twelve months of development will be extremely important. It is important that the velocity of NO_x adsorber development be sustained, that system integration strategies progress to the hardware stage, and that technology confirmation decisions be made by companies in order to prepare for 2007 product introduction.

3. Which refiners have announced their plans for producing low sulfur diesel fuel by June 2006? Where are refiners in their decision making/planning process for complying with the low sulfur diesel program requirements? Are the necessary resources and plans being put in place to ensure that refiners are on track for meeting the 15 ppm sulfur diesel standard in 2006?

There is a general agreement that there are no technological impediments to refineries proceeding with desulfurization and that in general refiners are where they are expected to be. In some cases, refiners have made the decision to desulfurize and have proceeded with

implementation ahead of schedule. Other refiners are still assessing their options as is appropriate at this point in time. In some cases, refiners have made and announced decisions on whether they will be producing 15 ppm fuel. The Panel is encouraged that projects, plans, and commitments already made by refiners to produce 15 ppm fuel by June 2006 account for 12.8% of today's highway diesel volume. Sufficient time remains for the refiners to assess their options, and they are making significant efforts to evaluate the resources required to comply with 2007 HD Rule.

In reaching these decisions, refiners are assessing technology alternatives and costs, the degree of desulfurization needed in order to comply with the 2007 HD Rule, possible requirements under future nonroad or other regulations, and market and other factors not directly related to the 2007 HD Rule but important to refinery decision-making. Indeed, the Panel is encouraged that most refiners are identifying strategies for compliance in the face of these uncertainties. None of these uncertainties is considered insurmountable at this time. EPA has indicated that it will continue to monitor these matters in the period between now and 2006 to identify and address any issues that emerge (by June 2003 and again in June 2004 and 2005 all refiners will be reporting to EPA their plans for compliance). This information will be shared back by EPA with the stakeholders in a timely fashion and in a non-confidential format to help make decisions for implementing the 2007 HD Rule in the most effective manner.

4. What is the current status of new or improved desulfurization technologies?

As anticipated, there have been introductions of new technologies for the desulfurization of diesel as well as improvements to the existing technology portfolio. Information presented during the review process confirmed that new technologies are being developed that will potentially be utilized to assist refiners in producing 15 ppm fuel from existing assets or that will potentially be able to produce 15 ppm fuel as a new stand alone application. Commercial demonstration plants are currently under construction in at least two new technologies; however, it is not clear at this time the extent to which the commercial demonstration plants will be operating and producing stable and consistent results in time for most refiners to rely on these emerging technologies to make their compliance decisions for 2006. The Panel recognizes that while there could be advantages to these emerging technologies over the longer term, they are not essential to attain compliance for 2006.

IV. EPA Workshops

As would be expected with the implementation of any important rule like the 2007 HD Rule, the Clean Diesel Independent Review Panel heard at its meetings of a number of subjects, some of which fell within the direct charter and questions directed by EPA to the Panel, and are addressed in the Panel's Conclusions. All comments and presentations from other industry experts and stakeholders have been forwarded on to EPA, and can be found in the CDIRP record at http://www.epa.gov/air/caaac/clean_diesel.html.

Some Panel members raised issues that they believe will significantly impact the ability of the refining, distribution, and delivery systems to meet consumer demand for fuels. The majority of the Panel concluded, however, that these issues were outside the scope of the Panel's charter. In response to these issues, EPA has initiated a series of meetings and public workshops on topics such as misfueling and sulfur measurement, and to facilitate a discussion about pipeline and distribution system operations. Future workshops will cover other fuels and engine issues. The Panel agreed that EPA's planned activities are an appropriate response to these issues at this time. Schedules for and records of these workshops can be found at <http://www.epa.gov/otaq/diesel.htm>.

V. Acknowledgments

The Panel would like to acknowledge several individuals for their invaluable assistance in preparing this report. First and foremost the Panel thanks Mary Manners, our Designated Federal Official, for her hard work, excellent communication, and "special" contributions to Panel energy levels, and to the staff of EPA for their information and presentations. We would also like to thank the many individuals who presented information to the panel and/or provided comments. Finally, we appreciate greatly the assistance of our contract support team Rebecca Battye and Kathy Boyer.

Endnotes

1. Air Quality Criteria for Ozone and Related Photochemical Oxidants. EPA/600/P-93/004aF-cF, July 1996. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.
2. Air Quality Criteria for Particulate Matter. EPA/600/P-95-001aF-cF, April 1996. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.
3. Air Quality Criteria for Particulate Matter and Sulfur Oxides. EPA-600/8-91/049aF-cF, December 1982. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.

Second Addendum to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of Newly Available Health Effects Information. EPA/600/8-86/020F, December 1986. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.

Supplement to the 2nd Addendum (1986) to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of New Findings on Sulfur Dioxide Acute Exposure Health Effects in Asthmatic Individuals. EPA/600/FP-93/002, August 1994. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.

4. Air Quality Criteria for Oxides of Nitrogen. EPA-600/8-91/049aF-cF, August 1993. USEPA, Office of Environmental Criteria and Assessments, Office of Health and Environmental Assessments, Office of Research and Development, Research Triangle Park, NC 27711.
5. Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements; Final Rule. EPA; 40 CFR Parts 69, 80, and 86. Federal Register/Vol. 66, No. 12, Thursday, January 18, 2001.
6. U.S. EPA, Office of Air and Radiation. *Highway Diesel Progress Review*. EPA420-R-02-016, June 2002. (<http://www.epa.gov/air/caaac/dieselreview.pdf>)
7. Charter of the Clean Diesel Independent Review Panel contained in letter of Holmstead, J.R., Assistant Administrator of the U.S. EPA to Clean Diesel Independent Review Subcommittee panel members. April, 16, 2002.
8. Holmstead, J.R., Assistant Administrator of the U.S. EPA to Clean Diesel Independent Review Subcommittee panel members. Invitation to serve on the panel. April, 16, 2002.

Appendix I
Presentations and Public Comment at
Review Subcommittee Meetings

May 23, 2002

Presentations

Cleaner Vehicles, Cleaner Fuel, & Cleaner Air: Overview of the 2007 Heavy-Duty Engine & Low Sulfur Diesel Fuel Program. Chet France, USEPA – Technical Advisor to the Panel

Public Commenters

John Miedley, ExxonMobil

Michael Osborne, NAVSEA

Peter Lidiak, American Petroleum Institute

Beth Law, American Trucking Association

Greg Scott, Collier Shannon (represents convenience store and truck stop owners, and petroleum marketers)

Frank O'Donnell, Clean Air Trust

Emily Figdor, US PIRG

June 27-28, 2002

Presentations

Cleaner Vehicles, Cleaner Fuel, & Cleaner Air. Byron Bunker, USEPA–Invited Guest Speaker. Mary Manners, USEPA–Designated Federal Official.

Path to 2007, EMA Presentation to the Clean Diesel Independent Review Panel. Jed Mandel, Engine Manufacturers Association–Invited Guest Speaker

Technological Progress Towards Meeting the 2007 On-Road Heavy-Duty Engine Emission Standards. Bruce Bertelsen, MECA–Panel Member. Tim Johnson, Corning–Panel Member.

July 30-31, 2002

Presentations

Fuel Industry's Response to EPA's CDIRP Progress Report. Mike Leister, Marathon Ashland Petroleum–Panel Member

Diesel Sulfur Test Methodology. Bob Schaefer, BP–Invited Guest Speaker

The Lower It Goes, The Tougher It Gets! Practical Implications of Producing ULSD. James Kennedy, UOP LLC–Panel Member

Reducing Diesel Fuel Sulfur with Phillips S Zorb Technology. Dennis Kidd, Phillips–Invited Guest Speaker

IsoTherming Technology. Michael Ackerson, Process Dynamics–Invited Guest Speaker

Path to 2007: EMA Comments on EPA’s June 2002 Highway Diesel Progress Review. Jed Mandel, EMA–Invited Guest Speaker

Mack Powertrain’s Comments on 2007 Feasibility. C.K. Salter, Mack–Invited Guest Speaker

Fuel Distribution Tutorial. Mike Leister, Marathon Ashland Petroleum–Panel Member

Marathon Ashland Petroleum LLC ULSD Testing. Wes Neff, Marathon Ashland Petroleum–Invited Guest Speaker

Colonial Pipeline Company: CDIRP Pipeline Issue Review. Buster Brown, Colonial Pipeline–Invited Guest Speaker

Public Commenters

Marc Goodman (consultant, speaking on his own behalf)

September 24-25, 2002

No Presentations or Public Commenters